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United States
Department
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Forest Service

**Intermountain
Research Station**

Research Note
INT-416

June 1993

Oxyfluorfen Safe to Use in Engelmann Spruce Seedbeds

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Abstract—Oxyfluorfen, a diphenylether herbicide, can be applied to Engelmann spruce nursery beds without significant damage to seedlings. Oxyfluorfen, applied at 0.5 lb/acre with preemergence timing for two years, reduced seedling dry mass. When the rate of herbicide application was reduced, the timing was delayed, or the applications were discontinued the second year, there was little damage to seedlings. Five of 10 herbicide treatments significantly reduced seedling densities compared to the no-treatment plots.

Keywords: herbicides, Goal, *Picea engelmannii*, weed control, forest nurseries

Oxyfluorfen, a broad spectrum herbicide in the diphenylether group, has been shown to be very effective in controlling broadleaf weeds and grasses on pine nursery beds (Abrahamson and Burns 1979; Heidmann and Haase 1985; Kozman 1989; Mason 1988; Sloan and Thatcher 1988; South and Gjerstad 1980; Thompson 1987, 1989). In general, preemergence application rates of 0.5 to 1.0 lb of active ingredient per acre (0.56 to 1.12 kg/ha) have provided good weed control with little or no damage to loblolly (*Pinus taeda* L.), slash (*Pinus elliottii* Engelm.), shortleaf (*Pinus echinata* Mill.), longleaf (*Pinus palustris* Mill.), Virginia (*Pinus virginiana* Mill.), eastern white (*Pinus strobus* L.), ponderosa (*Pinus ponderosa* Dougl. ex Laws.), Austrian (*Pinus nigra* Arnold), and lodgepole pine (*Pinus contorta* Dougl. ex Loud.), and white (*Picea glauca* [Moench] Voss) and Sitka spruce (*Picea sitchensis* [Bong.] Carr.).

Preemergence applications normally gave more complete weed control than postemergence applications. South and Mexal (1983) found that a preemergence rate of 1.0 lb/acre (1.12 kg/ha) reduced early growth of loblolly pine, while 0.5 lb/acre (0.56 kg/ha) did not. Even lower rates may be effective. Abrahamson and Burns (1979) reported that at four forest nurseries in the Great Plains 0.25 lb/acre (0.28 kg/ha) of Oxyfluorfen applied before seedling emergence reduced weed growth. Thompson (1987) achieved the same success with 0.22 lb/acre (0.25 kg/ha) as with 0.89 lb/acre (1.0 kg/ha) in Saskatchewan.

Some phytotoxicity has been reported. Limited tests at Mt. Sopris, CO, Coeur d'Alene, ID, and Lucky Peak, ID, Nurseries indicated that in rates of 0.75 to 1.50 lb/acre (0.84 to 1.69 kg/ha), Oxyfluorfen damaged Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) seedlings when applied before tree seedling emergence (Ryker 1979). At the same rates, postemergence applications appeared to be safe on Engelmann spruce.

In order that Oxyfluorfen could be used with confidence in Engelmann spruce nursery beds, I conducted a study to test the effect on seedling survival, size, and bed density using two application rates: 0.25 and 0.5 lb/acre at Lucky Peak Nursery near Boise, ID. This paper reports the results of that study.

METHODS

This phytotoxicity test was designed to determine if Oxyfluorfen applied in the nursery at either of two rates and different first-year timings would reduce survival or growth of Engelmann spruce seedlings. It was also designed to determine the effects of continuing herbicide treatments into the second growing season. All other nursery cultural practices, such as irrigation and fertilization, were conducted as usual.

The test was designed according to Sandquist and others (1981). The plots were set up in a randomized complete block arrangement with six blocks. Each block contained 10 plots treated with different combinations of dosage and time of application, plus one

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Table 1—Concentrations and timing of the Oxyfluorfen treatments. Treatments include preemergence (PS) or postgermination (PG) application, first year (1) or first and second year (1+2) applications, and application rates of 0.25 lb/acre active ingredient (1x) or 0.50 lb/acre active ingredient (2x)

	First year				Second year			
	May 3[1]		June 13[2]		April 22		June 19	
Treatment code	**0.25 lb/acre**	**0.50 lb/acre**	**0.25 lb/acre**	**0.50 lb/acre**	**0.25 lb/acre**	**0.50 lb/acre**	**0.25 lb/acre**	**0.50 lb/acre**
1x PS (1)	X							
1x PS (1+2)	X				X			
2x PS (1)		X						
2x PS (1+2)		X				X		
PS + PG (1)	X		X					
PS + PG (1+2)	X		X		X		X	
1x PG (1)			X					
1x PG (1+2)			X				X	
2x PG (1)				X				
2x PG (1+2)				X				X
No treatment								

[1] Oxyfluorfen applied 2 days after sowing.
[2] Oxyfluorfen applied 41 days after sowing.

untreated control plot. All plots were 3 ft (0.91 m) long with a 1-ft (0.30 m) buffer strip between them. They were located on one continuous 4-ft (1.2 m)-wide nursery bed. Table 1 shows the Oxyfluorfen concentrations and timing of application for each treatment.

I applied Oxyfluorfen evenly to the plots in a 4.5-ft (1.37 m) swath using an AZ small-plot pressurized sprayer. The emulsifiable, concentrated herbicide was diluted in a water carrier at a volume equivalent to 85 gal/acre (127 L/ha) or 100 mL per 3-ft (0.91 m) plot. Preemergence treatments were applied within 2 days after sowing (May 3, 1985). Postemergence spray was applied 4 to 5 weeks after seedling emergence (June 13, 1985). Second-year applications were made on April 22 and June 19, 1986. Application rates were 0.25 lb/acre (0.28 kg/ha) of active ingredient (1x concentration) and 0.5 lb/acre (0.56 kg/ha) of active ingredient (2x concentration). Nursery personnel conducted all other normal cultural activities as scheduled.

At the end of the first and second growing seasons I compared each treated plot to the control plot using an herbicidal damage rating scale (Anderson 1963). At the same time, I counted the number of live spruce seedlings and measured average heights in three 1-ft (0.30 m) sample rows in every plot. At the end of the second growing season I lifted the trees in all three sample rows, randomly selecting 10 trees to measure dry weights of shoots and roots. I analyzed the data using analysis of variance and single degree of freedom comparison of means.

RESULTS AND DISCUSSION

After the first year of the study, there was little difference in mean tree seedling height, mean seedling density, and mean damage rating for any of the treatments. Both application rates, 0.25 (1x) and 0.5 (2x) lb/acre, and preemergence (PS) and postemergence (PG) timings caused very little damage to Engelmann spruce seedlings during germination, establishment, and after one season of application. Nor did applications during the second growing season adversely affect the test seedlings in most cases (table 2). Figure 1 compares two plots in the same block. The first plot was treated with 0.25 lb/acre Oxyfluorfen preemergence and postemergence, both years. The second plot is an untreated control plot. The two photographs show little visible difference between the plots. Treated and control plots looked alike in most other plots in this block and in the other blocks.

Although the first-year mean heights for seedlings receiving each of the treatments were not significantly different from the mean height of control seedlings ($\alpha = 0.05$), the mean height of all seedlings receiving 2x treatments was only 3.05 cm, compared to 3.35 cm for all seedlings receiving 1x treatments and 3.40 cm for all seedlings in control plots. By the end of the second growing season, however, the height differences had disappeared (table 2).

The Damage Rating System used here was developed by Anderson (1963). Each plot in a block is subjectively compared to the control plot in that block and evaluated on a scale of 0 (complete mortality) to 10 (no damage). In this case, there was no difference between the mean Damage Rating of any of the plots treated with herbicide and the untreated plots ($\alpha = 0.05$) (table 2).

The mean number of seedlings per row ranged from a low of 16.5 on the plots with a 0.5-lb/acre preemergence application both years, to 21.4 on the untreated plots. Five treatments had seedling densities significantly lower than the untreated plots: 0.50-lb/acre postgermination application both years, 0.25-lb/acre pregermination

Table 2—Comparison of treatment plot means with control plot means: second-year phytotoxicity data for Oxyfluorfen on Engelmann spruce. Treatment abbreviations are explained in table 1

	Mean tree height		Mean No. of seedlings/ ft of row	Mean damage rating[1]	Mean dry weight		Mean dry weight/ ft of row
Treatment	**1st year**	**2d year**			**Shoot**	**Root**	
	cm				*g*		
1x PS (1)	3.0	8.8	18.1	9.8	1.07	0.71	31.21
1x PS (1+2)	3.4	8.1	20.9	9.8	1.10	.63	36.16
2x PS (1)	3.2	7.5	17.6	9.8	1.11	.69	31.68
2x PS (1+2)	2.9	7.3	[2]16.5	9.5	.90	.57	[2]24.26
1x PG (1)	3.5	7.9	[2]16.9	9.8	1.02	.73	29.58
1x PG (1+2)	3.4	8.0	[2]16.9	9.8	1.14	.69	30.93
2x PG (1)	3.0	8.5	17.7	9.5	1.01	.63	29.03
2x PG (1+2)	3.1	9.2	[2]17.1	9.3	1.28	[2].81	35.74
PS + PG (1)	3.3	7.3	[2]16.7	9.2	1.15	.68	30.56
PS + PG (1+2)	3.5	8.0	17.8	9.7	1.24	.75	35.42
No treatment	[3]3.4	[3]8.4	21.4	[3]10.0	[3].98	.61	34.03
Total average	3.2	8.1	17.9	9.7	1.09	.68	31.78

[1] Damage rating is based on "no treatment" plots and ranges from 10 (no damage) to 1 (complete mortality).
[2] Significantly different from the "no treatment" mean ($\alpha = 0.05$).
[3] No significant difference between any of the treatment means and the "no treatment" mean ($\alpha = 0.05$).

application the first year only, 0.25-lb/acre pregermination application both years, 0.50-lb/acre pregermination application both years, and 0.25-lb/acre pregermination and postgermination application the first year only. However, there did not seem to be any apparent relationship between mean seedling density and Oxyfluorfen concentration, application timing, or the years of application (table 2). Figure 2 compares mean densities of the 10 treatments with the control and shows how the densities of each treatment changed between the end of the first growing season and the end of the second.

Mortality after the first year was much higher than expected on all plots. Seedling density dropped 7 percent on control plots after the first year, compared with 10 to 22 percent (mean = 15) on the treated plots. Overall, there was little difference in the reductions in seedling density between the first and second year treatments and between the preemergence and postemergence applications. Seedling density was reduced

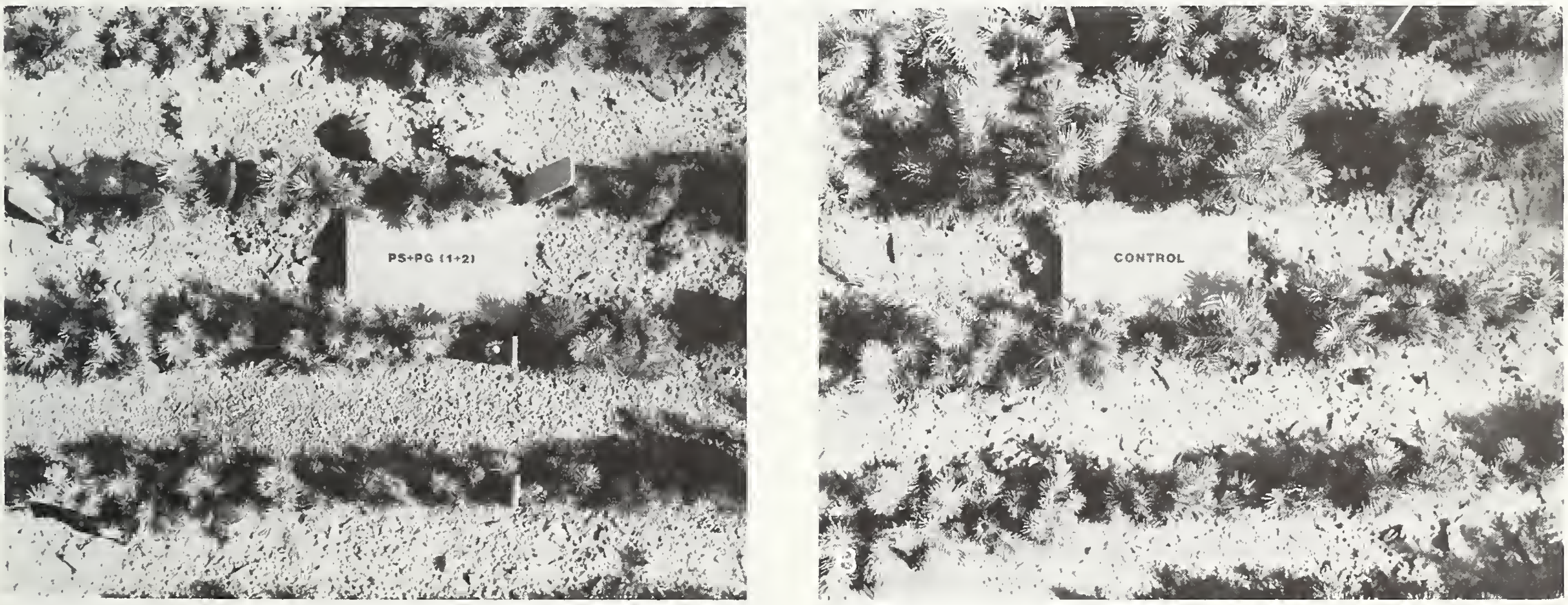

Figure 1—Photographs of a treatment plot (left) and the control plot (right) from the same block. Oxyfluorfen was applied to the treatment plot at both preemergence and postemergence timings at a rate of 0.25 lb/acre both years, treatment 1x PS+PG (1+2). No herbicide was used on the control plot.

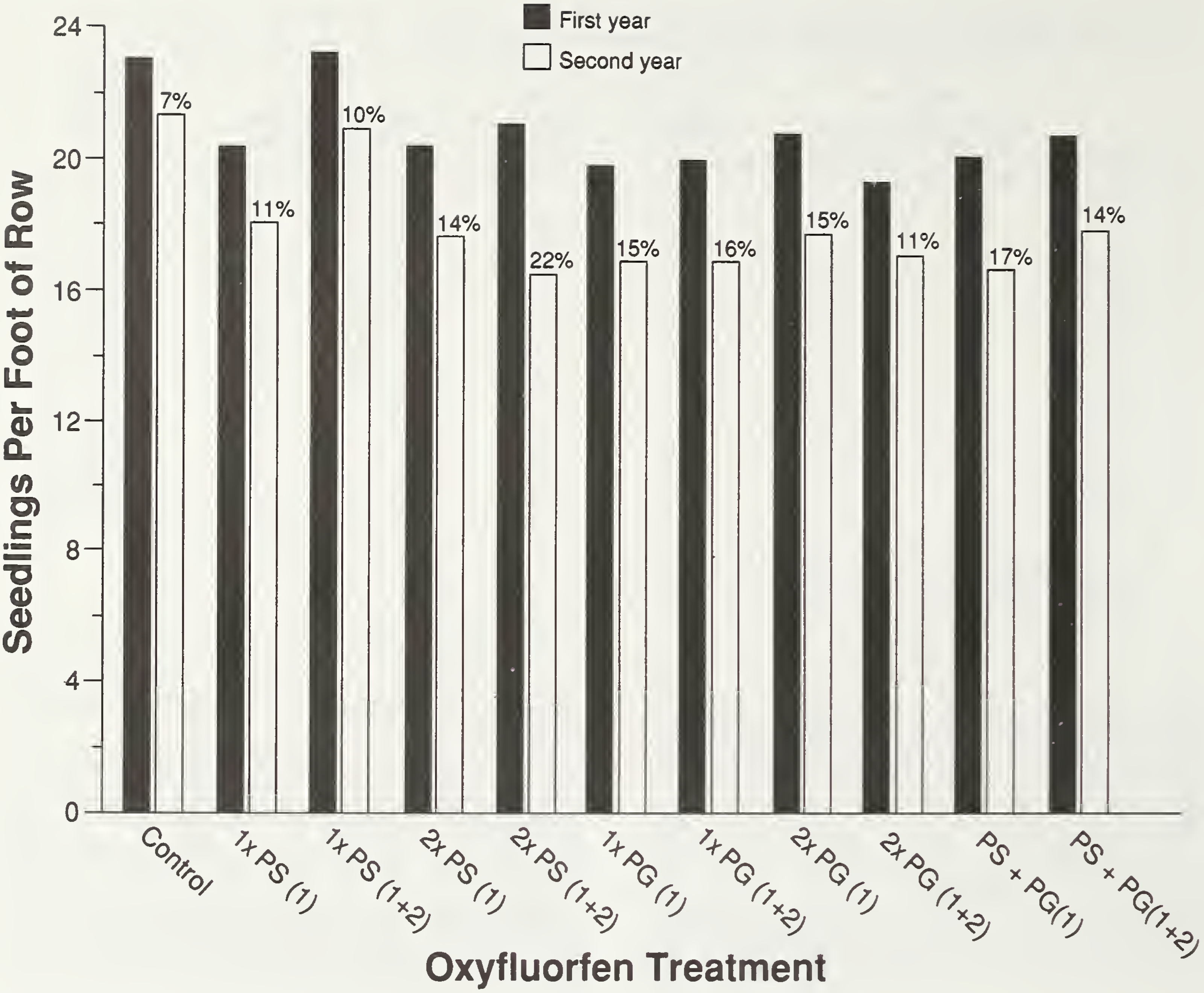

Figure 2—Effects of Oxyfluorfen treatments on density of Engelmann spruce seedlings in the nursery bed for the first and second growing seasons. Control = no treatment; 1x = 0.25 lb/acre active ingredient; 2x = 0.5 lb/acre active ingredient; PS = preemergence; PG = postemergence; 1 = first year only; 1+2 = first and second years. Table 1 explains when the treatments were applied. The numbers on top of the bars indicate the percent reduction in density after the first growing season.

more in the 2x concentration plots (16 percent) than in the 1x concentration plots (13 percent). These results are similar to those of a study using Oxyfluorfen on lodgepole pine where the preemergence applications were found to be more damaging (Sloan and Thatcher 1988).

None of the mean shoot dry weights for seedlings experiencing any of the treatments differed significantly from those of untreated seedlings. The mean root dry weight of seedlings treated with 0.5 lb/acre Oxyfluorfen applied postemergence both years was significantly greater than for seedlings in control plots. This is due, at least in part, to the lower density of plants in the treated plots, not because Oxyfluorfen enhanced root growth. Finally, one treatment produced much less mean total seedling dry weight per foot of row than the control. This treatment was the 0.5 lb/acre preemergence application continued into the second year. Its lower biomass production seems to be due to a combination of low seedling densities and low overall dry weights of both shoots and roots. This may very well be a sign that this treatment damaged seedlings because Oxyfluorfen was applied too many times at too concentrated a rate when the seedlings were too sensitive. The rest of the data in table 1 indicates that no one of these factors by itself injured the seedlings.

CONCLUSIONS

Oxyfluorfen can be safely applied to Engelmann spruce nursery beds without significant damage to seedlings. This is not to say that Oxyfluorfen will never injure Engelmann spruce seedlings. The above results suggest that Oxyfluorfen can adversely affect seedling growth and vigor. However, in the treatments used here, most of the adverse effects were not significant. When 0.5 lb/acre of Oxyfluorfen was applied at the preemergence timing both years, it did reduce the total dry mass per foot of row. This was the most obvious indication that certain combinations of herbicide concentration and timing could reduce seedling production. When the rate was reduced, when the timing was delayed, or when the application was discontinued the second year, the seedlings did not seem to be damaged as much.

Another indication that Oxyfluorfen might damage Engelmann spruce seedlings was the significantly lower mean seedling densities of five of the treatments compared to the untreated plots. However, because there did not seem to be any relationship between the herbicide concentration, application timing, and second year treatments, interpretation is difficult.

Even though the differences in first year mean heights are not significant, it appears that the 0.5 lb/acre rate could slightly stunt seedling heights. The effects were not permanent. The slight differences in height at the end of the first growing season were overcome during the second.

Although the ability of Oxyfluorfen to control weeds was not addressed in this study, other studies (Heidmann and Haase 1985; Richardson and others 1976; Schlesselman and Lange 1984; South and Gjerstad 1980) have reported adequate weed control using Oxyfluorfen at a preemergence rate of 0.5 lb/acre. Abrahamson and Burns (1979) and Thompson (1987) achieved success with 0.25 lb/acre. In most cases, preemergence applications have been most effective in reducing weeds.

Overall, the Oxyfluorfen applications did not cause visible seedling damage. Care should be observed when spraying Oxyfluorfen on Engelmann spruce nursery beds at the 0.5 lb/acre (active ingredient) concentration. The lower total seedling dry weight (table 2) and the big reduction in seedling density after the first growing season warn us not to apply 0.5 lb/acre Oxyfluorfen before emergence 2 years in a row. The postgermination application and the 0.25 lb/acre rate can be safely used on Engelmann spruce seedbeds.

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